

Forensic Audio Analysis Report

Prepared at the request of Rollande J. Adolphe, Esq., attorney, Lake Worth, Florida.

Topic: BRYANT GRANT, Plaintiff, v. THE CITY OF WEST PALM BEACH and ROMARIO A. SAUNDERS, individually, Defendants.

Report prepared by:

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Date: 19 August 2025

Contents: Report (10 pages) and attached CV (16 pages)

Introduction

This report was prepared at the request of Ms. Rollande J. Adolphe, attorney representing Bryant Grant, in West Palm Beach, Florida. I was first contacted by Ms. Adolphe on August 11, 2025, regarding a case in which a ShotSpotter system had reported possible gunshot sounds on August 12, 2023, at approximately 11:03PM. Ms. Adolphe explained that law enforcement officers were dispatched in response to the ShotSpotter report, but instead of being sent to the specific latitude and longitude identified by ShotSpotter, the officers were sent to an address on a different street than the estimated location. Ms. Adolphe then provided me with a copy of the ShotSpotter "Investigative Lead Summary" and an audio recording of the police dispatch radio conversations.

I performed an initial review of the information and exchanged email with Ms. Adolphe regarding the audio forensic aspects of gunshot sounds and the general functionality of the ShotSpotter system. I received an email from Ms. Adolphe on August 15, 2025, indicating her interest to hire me as an audio forensic consultant on the case at my standard rate of \$250/hour. I was asked to prepare this report regarding my interpretation of the ShotSpotter report and the addresses involved.

It is my understanding that the ShotSpotter report, audio recordings, and related information were obtained as part of routine and official law enforcement activity, and that I was provided with the best available copy of the recordings and other material. I have no prior knowledge of any other aspects of this case and have no connection to the parties involved. I have not visited the scene of the incident, nor have I performed any physical testing or analysis. I have not spoken with anyone about this case except Ms. Adolphe.

This report is organized as follows. First, I provide a brief summary of my qualifications and expertise. Next, I describe my interpretation of the way in which the ShotSpotter information was used, and consider the query given to me by Ms. Adolphe.

Qualifications

My professional Curriculum Vitae (CV) is attached to this report. Please allow me to summarize my qualifications and professional background in the field of audio forensic analysis.

I am currently a full Professor with the Electrical & Computer Engineering Department at Montana State University, Bozeman, MT. I have been affiliated with Montana State University since 2002. I am also the sole proprietor of a consulting firm specializing in audio digital signal processing and audio forensics. This report is provided under the auspices of my consulting practice, not as an official part of my responsibilities to Montana State University.

I received the BS degree from Washington University (St. Louis) in 1984, the MS degree from the University of Wisconsin (Madison) in 1985, and the PhD from the University of Illinois (Urbana-Champaign) in 1989, all in the field of electrical engineering. My career has also included university faculty positions with the University of Nebraska-Lincoln and the University of Colorado-Boulder, as well as experience in the digital audio signal processing industry as an entrepreneur and engineering manager.

I am a licensed Professional Engineer in the State of Montana (License no. 18993), a Fellow of the Audio Engineering Society, a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE), and an Associate Member of the American Academy of Forensic Sciences. I am also a member of the Acoustical Society of America, the American Society for Engineering Education, and a duly inducted member of the Eta Kappa Nu, Tau Beta Pi, Phi Kappa Phi, and Sigma Xi professional honorary societies. I publish research in the field of audio forensics, and I serve as Deputy Editor-in-Chief of the Journal of the Audio Engineering Society. My academic research includes three successive competitively-awarded grants for audio forensic research from the U.S. Department of Justice-National Institute of Justice.

I have consulted on more than fifty prior formal audio forensic investigations, and I have analyzed dozens of evidentiary recordings in the course of my more than 30 years working professionally in the audio signal processing field. I have previously been qualified as an expert witness in California, Massachusetts, Montana, Missouri, Ohio, Washington D.C., and Texas, and I have provided sworn testimony in court nine times, and been deposed nine times.

A selection of my publications, book chapters, and presentations relevant to the field of forensic audio analysis are listed here. My CV includes a complete list of professional publications.

R.C. Maher, "Interpreting user-generated recordings from the Trump assassination attempt on July 13, 2024," Proc. 187th Meeting of the Acoustical Society of America—Virtual, November 21, 2024.

R.C. Maher, "Close and Distant Gunshot Recordings for Audio Forensic Analysis," Express Paper 122, Proc. 155th Audio Engineering Society Convention, New York, NY, October, 2023.

R.C. Maher, "Interpretation of audio forensic information from the shooting of journalist Shireen Abu Akleh," Express Paper 22, Proc. 153rd Audio Engineering Society Convention, New York, NY, October, 2022.

R.C. Maher, *Principles of Forensic Audio Analysis*, book, Springer Publishing, 2018.

R.C. Maher, "Gunshot recordings from a criminal incident: who shot first?" J. Acoust. Soc. Am., vol. 139, no. 4, part 2, p. 2024 (abstract), April, 2016.

R.C. Maher, "Lending an ear in the courtroom: forensic acoustics," Acoustics Today, vol. 11, no. 3, pp. 22-29, 2015.

R.C. Maher, "Audio forensic examination: authenticity, enhancement, and interpretation," IEEE Signal Processing Magazine, vol. 26, no. 2, March, 2009.

R.C. Maher, "Acoustical characterization of gunshots," Proc. IEEE SAFE 2007: Workshop on Signal Processing Applications for Public Security and Forensics, Washington, DC, pp. 109-113, April, 2007.

R.C. Maher, "Modeling and signal processing of acoustic gunshot recordings," Proc. IEEE Signal Processing Society 12th DSP Workshop, Jackson Lake, WY, pp. 257-261, September, 2006.

Initial Examination of the Material

As indicated above, Ms. Adolphe asked me to interpret the following files:

1. ILS_2023-08-12_23-03-52_9th-Ct_754-305997 (1).pdf
2. 20230013975_Redacted Incident Report.pdf
3. 23-13975Radio.wav

The first file is ShotSpotter's Investigative Lead Summary report, ShotSpotter ID 754-305997. The second file is a copy of the West Palm Beach Police Department "Incident Report," case number 2023-0013975. The third file is an audio recording, approximately 13 minutes 20 seconds in duration, that appears to be spoken dialog recorded from the police dispatch radio channel.

Ms. Adolphe's specific requests were:

1. Review the attached discovery and identify any gaps in the ShotSpotter data or reporting that we should request.
2. Assess whether the available information is sufficient to establish the likelihood of a location error or misinterpretation.
3. Advise on any technical, environmental, or procedural factors that could have caused a false or misleading alert.
4. Let us know if there are additional documents, logs, or metadata we should subpoena from the vendor or agency to strengthen this analysis.

The ShotSpotter Investigative Lead Summary (ILS) report gives the time and estimated location of the likely gunshot sounds, as shown in Figure 1. The ILS report gives latitude and longitude coordinates that correspond to the center of the 25 meter radius uncertainty circle shown in the figure.

The figure shows the likely shot location identified by ShotSpotter to be a sidewalk on the east side of southbound Golf Avenue. Specifically, the likely shot location identified by ShotSpotter is on the west side of the water-filled canal that separates the southbound and northbound sections of Golf Ave. However, I note that the street address listed in the ILS report is "1387 9th Ct," which is an address located more than 25 meters east of the indicated shot location and across the water-filled canal.

The police department Incident Report lists the incident location as "1387 9th CT, West Palm Beach, FL 33401." Therefore, the report appears to indicate that the dispatched officers were at or near the indicated location on 9th Ct.

The audio recording of the dispatcher communications begins with a brief audible tone, 1kHz, about 1 second in duration. The first audible utterance starts approximately 6 seconds into the recording.

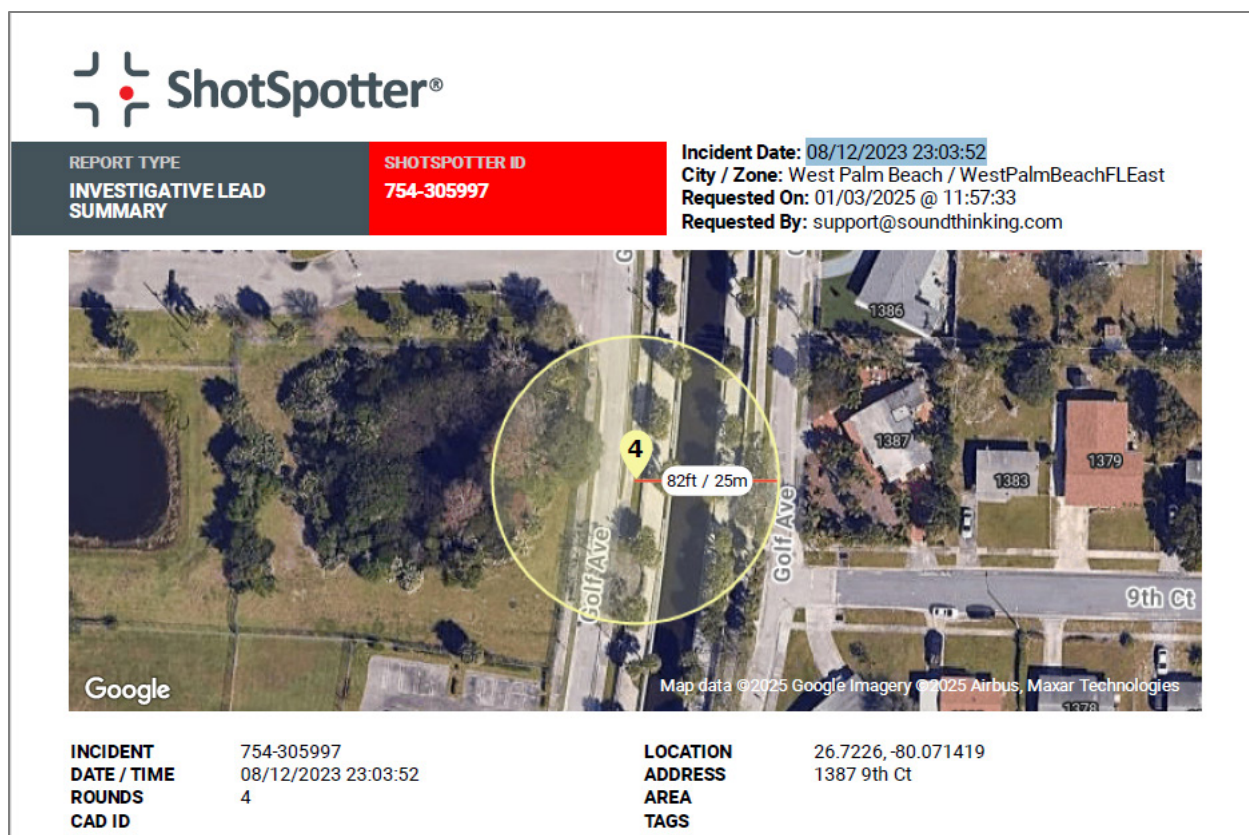


Figure 1: Portion of the ShotSpotter Investigative Lead Summary for this incident. The report identifies four likely gunshot sounds, and places them near a sidewalk on the east side of Golf Avenue, west of a water-filled canal. However, the street address "Location" is for a street east of the canal.

Interpretation of the ShotSpotter Report and the Incident

Following my initial review of the material, I considered Ms. Adolphe's concern regarding the assertion of a "location error or misinterpretation" from the ShotSpotter report. Therefore, it is helpful to understand that basic principles of the ShotSpotter system and its functions.

ShotSpotter system summary

A conventional firearm produces a muzzle blast (gunshot "bang") sound as the propellant in the ammunition cartridge burns rapidly and expels the bullet out of the firearm's barrel. The ShotSpotter® system from SoundThinking™ is a commercial, proprietary system intended to detect and localize muzzle blast sounds so that law enforcement officers can be dispatched quickly. A ShotSpotter system, like the system implemented in West Palm Beach, consists of numerous microphones and computer processing systems (sensor nodes) installed on rooftops, poles, and other structures in a neighborhood within a law enforcement agency's jurisdiction. The law enforcement agency must subscribe to ShotSpotter's dispatching service, which uses information derived from the acoustic sensors to make a judgement about the occurrence of a sound that might be a muzzle blast. When ShotSpotter's system makes a judgement that a sound might be a gunshot, the acoustic information is used to make an estimate of the geographic location of the sound source. The proprietary system uses signal processing algorithms and human listeners.

The number of ShotSpotter acoustic sensor nodes and their geographic dispersion varies from jurisdiction to jurisdiction. For example, SoundThinking reports that the system in West Palm Beach covers 4.6 square miles. The geometric coordinates of each sensor node are determined by an integrated GPS receiver at each node. The local clock at each node is also time-synchronized via the integrated GPS receiver. The sensor nodes include a processor system to record and analyze audio digitized from the microphone, and a communication system linking each sensor to ShotSpotter's central office.

The basic theoretical principle of the ShotSpotter system is that a loud, impulsive sound (such as the muzzle blast of a firearm) will travel through the air in all directions and be detectable at one or more of the acoustic sensor nodes. The time-of-arrival of the impulsive sound at the various sensors depends upon the distance between the sound source and the sensor, and the speed of sound. Since the sensors have synchronized clocks, theoretically the sound arrival time at each sensor can be determined. The audio processing system at each sensor node includes a computer program that uses various proprietary algorithms to estimate the likelihood that a received sound is a gunshot, and not some other common sound like a door slamming or a firecracker. If the algorithm makes the determination that a gunshot sound was observed, the system processes the recorded waveform and estimates the arrival time of the impulsive sound based upon the details of the microphone signal, and this information is sent to the ShotSpotter central office.

When the ShotSpotter central office has received several reports with closely synchronized time stamps from the acoustic sensor nodes in a particular area, the central office system automatically uses the time reports and the known sensor locations to estimate the time difference between the sound's earliest arrival at a sensor—presumably the sensor closest to the sound source—and the arrival times at the other sensors. The known location of each sensor and the measured time-difference of arrival at each sensor can, theoretically, be used to compute an estimate of the sound source location. This mathematical computation is known as *multilateration*.

Theoretically, the sound arrival times from at least three sensor nodes are needed for the mathematical multilateration to compute a set of possible sound source locations that are consistent with the observed time-differences of arrival, and at least four sensor nodes are needed to reduce the ambiguity of the possible source positions.

In order to notify the law enforcement agency about the possible muzzle blast detection so that the agency's officers can be dispatched, ShotSpotter uses a human observer to review the automatic system report, listen to the audio recordings from one or more sensors, and either confirm, manually re-locate, or cancel the detection. If the human listener confirms that the unknown sound is likely to be gunfire and likely to be at the estimated location, ShotSpotter reports an estimated location in two dimensions (e.g. latitude and longitude) to the law enforcement agency. The ShotSpotter report also generally includes a conversion of the geographic latitude and longitude coordinates into a street address. It is my understanding that the conversion of lat/long to street address takes place automatically using geographic database software, such as the Google map database shown in the ILS report.

The practical real-world performance of a sound localization system such as ShotSpotter will inevitably differ from theoretical calculations and predictions due to the effects of obstacles between the sound source and the microphones, the effects of sound echoes and reverberation, wind and temperature variations, noise picked up by the microphones, and other acoustical challenges. Therefore, ShotSpotter gives a 25 meter (82 feet) radius circle around their calculated sound source position to represent the uncertainty in their location estimate. The practical expectation is that the dispatched law enforcement officers will go to the indicated most likely origin (center of the circle) to look for evidence, then broaden the search out from that estimated position. ShotSpotter literature indicates that some percentage of location estimates will be inaccurate by more than the stated 25 meter radius, and not every actual gunshot sound will be detected and reported. Moreover, ShotSpotter's ILS report of this incident gives a disclaimer: *"Nothing herein shall to any extent substitute for the independent investigation of the shooting incident. The data and conclusions herein should be corroborated with other evidentiary sources such as recovered shell casings and witness statements."*

ShotSpotter report in this case

The ShotSpotter Investigative Lead Summary report for this incident includes an estimated latitude and longitude of the likely gunfire sounds, a Google Maps figure depicting the vicinity and showing the 25 meter radius uncertainty, the number of estimated gunshots in the sequence (four in this case), and a street address ("1387 9th Ct" in this case).

A Google Earth view of the location identified in the ShotSpotter ILS is shown in Figure 2. Note that ShotSpotter's identified latitude and longitude is on the west side of the canal, while ShotSpotter's identified street address is on the east side of the canal.



Figure 2: A Google Earth view of the incident vicinity. The added labels identify the ShotSpotter position west of the canal, and the ShotSpotter street address east of the canal. Note: 9th Ct does not cross over the canal.

My observation is that the ShotSpotter assigned street address is incorrect, given ShotSpotter's calculated latitude and longitude. Using ShotSpotter's assigned estimate of the likely shot location, it seems reasonable that the responding officers should have been sent to a location on Golf Ave (southbound) where the system placed the source, not to an address on the east side of the canal.

A closer view of the incident location is shown in Figure 3, indicating that the canal separation between southbound and northbound Golf Ave includes two railings and a fence on both the east side and the west side of the canal, preventing crossing except a block south at 9th St or a block north at 10th St.

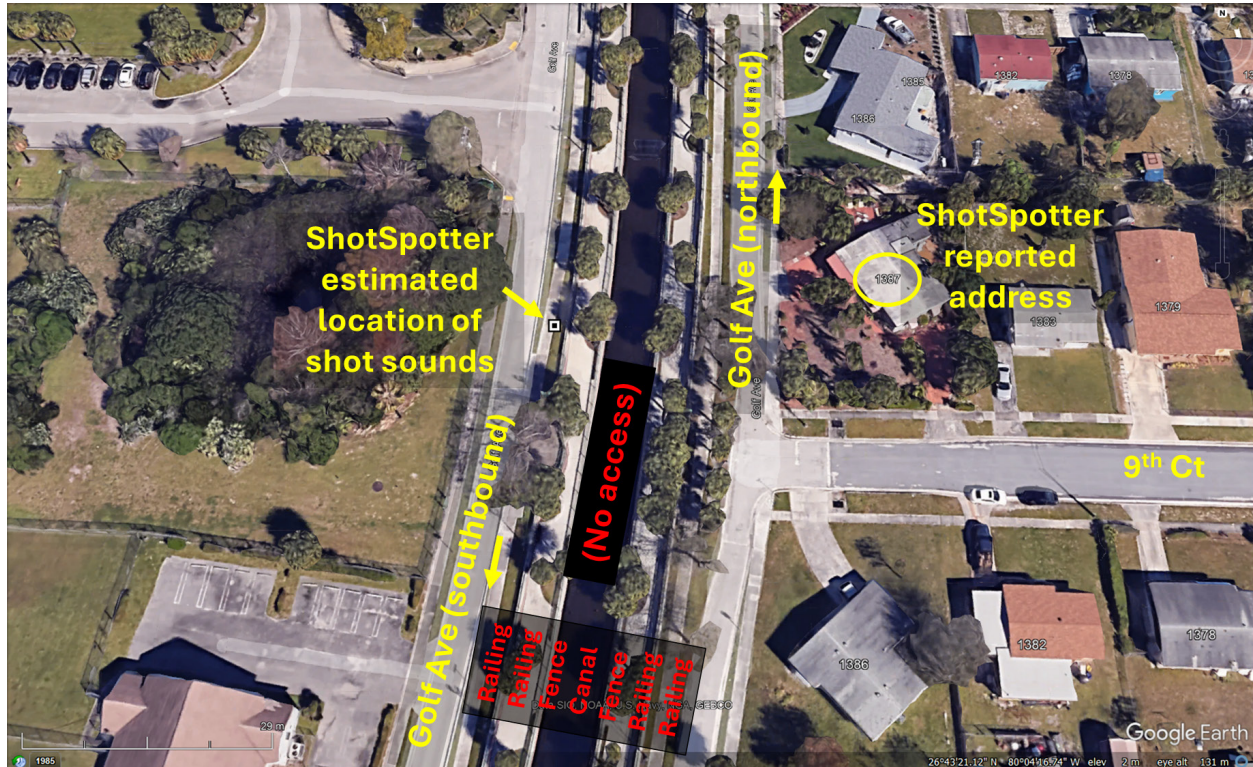


Figure 3: A Google Earth view of the incident vicinity. The added labels show that the canal blocks access from the ShotSpotter location to the 9th Ct street address.

Dispatcher directions based upon ShotSpotter report in this case

As noted previously, the dispatcher audio recording begins with a brief audible tone, 1kHz, about 1 second in duration. Beginning at approximately 6 seconds into the recording, I hear an utterance by the dispatcher, followed by several successive spoken remarks. My subjective interpretation of the relevant spoken words are:

Omin6sec (dispatcher):

“division one, ShotSpotter, thirteen eighty seven ninth court, one three eight seven ninth court, <unintelligible> four rounds.”

1min22sec (dispatcher):

“...units responding to ShotSpotter, just fourteen, it’s showing over Golf Avenue just north of ninth court.”

2min25sec (dispatcher):

“...division one for ShotSpotter, thirteen eighty seven ninth court.”

2min46sec (dispatcher):

“bravo one what is your exact twenty”

2min53sec (officer):

“in front of the twenty”

The initial statement by the dispatcher at 6 seconds elapsed time directs the responding officers to the ShotSpotter-reported street address “1387 9th Ct.” The audio and the incident reports appear to indicate that the responding officers went to that street address.

The dispatcher broadcasts at 1:22 elapsed time that “...units responding to Shot Spotter, just fourteen, it’s showing over Golf Avenue just north of ninth court.” The word “fourteen” likely indicates a message “10-14,” which means “for your information.” The dispatcher’s statement could be interpreted to mean that the dispatcher reviewed the ShotSpotter latitude and longitude and noted that the indicated shot location was near the southbound side of Golf Ave west of the canal, not the street address given on 9th Ct. However, the dispatcher’s statement does not indicate the relative position of the shot location to be on the west side of the canal, and there is no indication that the responding officers understood that the ShotSpotter location was actually on the west side of the canal (Southbound Golf Ave), not on 9th Ct.

The dispatcher repeats the street address 1387 9th Ct at 2:25 elapsed time, and then a responding officer confirms that the location (their “twenty” likely indicates “10-20,” which means “location”) is at that address.

I found no indication in the material provided to me that any responding officers went to the location on Golf Ave indicated by the latitude and longitude determined by ShotSpotter.

Conclusions

Based on both my preliminary and my additional examination and interpretation of the evidence provided to me, and my consideration of the technical aspects of the ShotSpotter system, it is my opinion to a reasonable degree of scientific certainty in the field of forensic audio analysis that the street address provided by ShotSpotter was not an accurate indication of where ShotSpotter’s multilateration calculation placed the likely sound location. The latitude and longitude information calculated by ShotSpotter shows the estimated location to be on southbound Golf Ave west of the Westward Park canal. However, the corresponding street address in the ShotSpotter Investigative Lead Summary report, which was the address used to dispatch the responding law enforcement officers, was on the east side of the canal. I find

that this discrepancy between the likely gunshot sound location determined by ShotSpotter and the street address used for dispatching officers led to the officers going to a location not consistent with the ShotSpotter multilateration calculation.

This concludes my findings regarding the ShotSpotter interpretation question posed to me by Ms. Adolphe. In the event that at some point in the future I should receive additional information, clarification, and/or new evidence related to this investigation, I reserve the right to amend this report to include my findings and opinions based upon review of the new information.

A handwritten signature in blue ink, appearing to read "Robert C. Maher", written over a horizontal line.

Robert C. Maher, Ph.D., P.E.

August 19, 2025

Date

ROBERT C. MAHER, PH.D., P.E.

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PROFESSIONAL EXPERIENCE

MONTANA STATE UNIVERSITY, Bozeman, Montana

2002-PRESENT

Professor of Electrical and Computer Engineering with tenure (7/08 – present)

Affiliate Professor of Music Technology (05/09-present)

Chair-Elect of MSU Faculty Senate (08/24-present)

Department Head, Electrical and Computer Engineering (8/07-8/17)

Associate Professor of Electrical and Computer Engineering with tenure (5/05-8/07)

Associate Professor of Electrical and Computer Engineering (8/02-5/05)

- ◆ Academic administration, teaching, research and service responsibilities.
- ◆ Established a funded research program in audio DSP.
- ◆ Teaching a variety of courses at both the undergraduate and graduate levels.

UNIVERSITY OF COLORADO, Boulder, Colorado

2001-2002

Associate Professor Adjunct of Electrical and Computer Engineering

- ◆ Academic instructional assignment for Senior Design Lab, and DSP Microprocessor Lab.

EUPHONICS, INC./3COM CORPORATION/U.S. ROBOTICS CORPORATION

1997-2001

EUPHONICS was acquired by 3COM in 1998 and spun off as part of U.S. ROBOTICS in 2000.

Engineering Manager, Research and Development, U.S. ROBOTICS (6/00-6/01)

Engineering Manager for Audio Product Development, 3COM (11/98-6/00)

Vice President of Engineering, EUPHONICS (5/97-11/98)

Director of Engineering, EUPHONICS (1/97-5/97)

- ◆ Hands-on experience creating new DSP algorithms, publications, and patents.
- ◆ Hired, trained and supervised ten DSP software engineers (including guidance, annual evaluations, and individual goal setting).

UNIVERSITY OF NEBRASKA, Lincoln, Nebraska

1989-1997

Associate Professor of Electrical Engineering with tenure (8/95-1/97)

Assistant Professor of Electrical Engineering (8/89-8/95)

- ◆ Initiated and directed a funded research and teaching program in audio DSP.
- ◆ Supervised theses of 19 graduate students in the field of digital audio signal processing.

AUDIO DSP CONSULTING

1989-PRESENT

Sole Proprietor, Consulting and Contracting Professional Services

- ◆ Consulting services to clients in digital signal processing for audio and entertainment products.
- ◆ Supervision of sub-contractors for embedded software development.

PROFESSIONAL EXPERIENCE (cont.)

UNIVERSITY OF ILLINOIS, Urbana, Illinois

1985-1989

Research Assistant, Electrical Engineering

- ◆ Software development for digital audio applications and musical acoustics demonstrations (DSP and Intel assembler, and C).

EDUCATION

Ph.D. - Electrical Engineering, University of Illinois,
College of Engineering, Urbana, Illinois, 1989

Thesis: "An Approach for the Separation of Voices in Composite Musical Signals"

Thesis Advisor: James W. Beauchamp

MS - Electrical Engineering, University of Wisconsin,
College of Engineering, Madison, Wisconsin, 1985

Report: "Development of a Software-Based Real-Time Digital Synthesizer"

BS - Electrical Engineering, *Magna Cum Laude*, Washington University,
School of Engineering, St. Louis, Missouri, 1984

RESEARCH FUNDING SPONSORS (COMPETITIVE)

National Institute of Justice, U.S. Department of Justice

KEEN Foundation

National Science Foundation

U.S. National Park Service

NASA/Montana Space Grant Consortium

The Engineering Foundation

Advanced Acoustic Concepts, Inc.

Ariel Corporation

EuPhonics, Inc.

General Atomics, Inc.

Motorola Corporation, DSP Support

Sanchez Industrial Design, Inc.

Northwest Academic Computing Consortium

MSU Space Science and Engineering Laboratory

Montana Institute on Ecosystems

University of Illinois Research Board

UNL Center for Communication and Information Science

Nebraska Research Initiative

LEADERSHIP ACTIVITIES and PROFESSIONAL AFFILIATIONS

- ◆ Licensed Professional Engineer, Montana, License #18993
- ◆ Fellow, Audio Engineering Society
- ◆ Senior Member, Institute of Electrical and Electronics Engineers (IEEE)
- ◆ Member, Acoustical Society of America
- ◆ Member, American Society for Engineering Education
- ◆ Associate Member, American Academy of Forensic Sciences
- ◆ Deputy Editor-in-Chief, Journal of the Audio Engineering Society (2022-2024)
- ◆ Associate Technical Editor, Journal of the Audio Engineering Society (2007-2024)
- ◆ Review Board Member, Audio Engineering Society (1998-present)
- ◆ Papers Co-Chair, Audio Engineering Society 141st Convention (2016)
- ◆ Papers Co-Chair, Audio Engineering Society 137th Convention (2014)
- ◆ Papers Co-Chair, Audio Engineering Society 129th Convention (2010)
- ◆ Papers Co-Chair, Audio Engineering Society 125th Convention (2008)
- ◆ Papers Co-Chair, Audio Engineering Society 121st Convention (2006)
- ◆ Papers Co-Chair, Audio Engineering Society 117th Convention (2004)
- ◆ Student Technical Paper Awards Coordinator, Audio Engineering Society (2008-2024)
- ◆ Chairman, Audio Engineering Society Colorado Section (1998-2001)
- ◆ Member, Audio Engineering Society Technical Committee on Audio Forensics
- ◆ Member, Audio Engineering Society Technical Committee on Signal Processing
- ◆ International Program Committee member, IEEE Electro Information Technology conference (2005)
- ◆ Publications Chair, IEEE Digital Signal Processing Workshop (2006)
- ◆ Chairman, IEEE Nebraska State Section (1995-1996)
- ◆ Chairman, IEEE Central Montana Section (2017-2019)
- ◆ Publications Chair, IEEE Workshop Applications of Signal Processing to Audio & Acoustics (1995)
- ◆ MSU Sigma Xi (Scientific Research Society) chapter co-president (2007-present)
- ◆ MSU Campus Advising Action Team (CAAT) (2016-2024)
- ◆ MSU Planning Council Representative for College of Engineering (2011-2015, 2018-2023)
- ◆ MSU Graduate Council Representative for College of Engineering (2003-2009)
- ◆ MSU Advising Council Representative for College of Engineering (2005-2007)
- ◆ External Advisory Board, University of Nebraska Electrical Engineering (1998-2000)
- ◆ FCC Amateur Radio License, Amateur Extra class, Call Sign NR7B

ACADEMIC HONOR SOCIETIES

Tau Beta Pi, Eta Kappa Nu, Phi Kappa Phi, and Sigma Xi.

AWARDS and HONORS

- ◆ MSU Faculty Senate Chair-Elect (2024-2025)
- ◆ MSU Provost's Award for Exemplary Service and Fidelity to the Public Land-Grant Mission (2023)
- ◆ MSU President's Award for Excellence in Teaching (2022)
- ◆ MSU College of Engineering Advising Award (2020)
- ◆ MSU Anna K. Fridley Phi Kappa Phi Award for Distinguished Teaching (2020)
- ◆ MSU Vice President for Research Award for Meritorious Technology/Science (2019)
- ◆ MSU College of Engineering Outreach Award (2017)
- ◆ MSU Academic Advising Award (2013)
- ◆ National Academic Advising Association (NACADA) Outstanding Faculty Advisor Award (2012)
- ◆ MSU James and Mary Ross Provost's Award for Excellence (2009)
- ◆ U. of Nebraska College Distinguished Teaching Award (1995)
- ◆ U. of Nebraska Parents' Association Recognition Award for Contributions to Students (1991, 93, 94)
- ◆ U. of Nebraska IEEE Student Chapter: Outstanding Faculty Award (1990, 1994); Tau Beta Pi: Outstanding Teacher Award (1993); College of Engineering: College Teaching Award (1992)

SCHOLARSHIPS/FELLOWSHIPS

- ◆ NSF Graduate Fellowship
- ◆ Audio Engineering Society Educational Grant
- ◆ University of Illinois and University of Wisconsin Graduate Fellowships
- ◆ Washington University Langsdorf Undergraduate Fellowship
- ◆ National Merit and National Honor Society Scholarships

UNITED STATES PATENTS

- (4) D. Kosek and R.C. Maher, "Audio Spectral Noise Reduction Method and Apparatus," Patent Number 7,742,914, June 22, 2010.
- (3) R.C. Maher and J. Barish, "Scalable Audio Processing on a Heterogeneous Processor Array," Patent Number 6,301,603, October 9, 2001.
- (2) R.C. Maher, "Audio Spatial Enhancement Apparatus and Methods," Patent Number 6,111,958, August 29, 2000.
- (1) R.C. Maher, "Audio Spatial Localization Apparatus and Methods," Patent Number 6,078,669, June 20, 2000.

FULLY REFEREED JOURNAL ARTICLES

These are formal papers invited or accepted for scholarly publication based on full peer review of the completed manuscript.

- (16) R.C. Maher, "Audio forensic interpretation of the Trump rally assassination attempt (13 July 2024)," J. Audio Eng. Soc., accepted for publication, to appear 2025.
- (15) H. Fraser, V. Aubanel, R.C. Maher, C. Mawalim, X. Wang, P. Počta, E. Keith, G. Chollet, K. Pizzi, "Forensic Speech Enhancement: Toward Reliable Handling of Poor-Quality Speech Recordings Used as Evidence in Criminal Trials," J. Audio Eng. Soc., vol. 72, no. 11, pp.748-753, 2024.
- (14) R.C. Maher, "Lending an ear in the courtroom: forensic acoustics," Acoustics Today, vol. 11, no. 3, pp. 22-29, 2015.
- (13) R.C. Maher, "Audio forensic examination: authenticity, enhancement, and interpretation," IEEE Signal Processing Magazine, vol. 26, no. 2, March, 2009.
- (12) R.C. Maher, "Control of synthesized vibrato during portamento musical pitch transitions," J. Audio Eng. Soc., vol. 56, no. 1/2, pp. 18-27, 2008.
- (11) Z. Chen and R.C. Maher, "Analytical expression for impulse response between two nodes in 2-D rectangular digital waveguide mesh," IEEE Signal Processing Letters, vol. 15, pp. 221-224, 2008.
- (10) Z. Chen and R.C. Maher, "Semi-automatic classification of bird vocalizations using spectral peak tracks," J. Acoust. Soc. Am., vol. 120, no. 5, pp. 2974-2984, 2006.
- (9) R.C. Maher, "Wavetable synthesis strategies for mobile devices," J. Audio Eng. Soc., vol. 53, no. 3, pp. 205-213, 2005.
- (8) P.K. Ramarapu and R.C. Maher, "Methods for reducing audible artifacts in a wavelet-based broad-band denoising system," J. Audio Eng. Soc., vol. 46, no. 3, pp. 178-190, 1998.
- (7) S.M. Joseph and R.C. Maher, "Subjective evaluation of four low-complexity audio coding schemes," J. Acoust. Soc. Am., vol. 97., no. 6, pp. 3657-3662, 1995.
- (6) R.C. Maher, "A method for extrapolation of missing digital audio data," J. Audio Eng. Soc., vol. 42, no. 5, pp. 350-357, 1994.
- (5) R.C. Maher and J.W. Beauchamp, "Fundamental frequency estimation of musical signals using a Two-Way Mismatch procedure," J. Acoust. Soc. Am., vol. 95., no. 4, pp. 2254-2263, 1994.
- (4) R.C. Maher, "On the nature of granulation noise in uniform quantization systems," J. Audio Eng. Soc., vol. 40, no. 1/2, pp. 12-20, 1992.

- (3) R.C. Maher, "A method for envelope warping in digital audio synthesis," J. Audio Eng. Soc., vol. 39, no. 12, pp. 934-944, 1991.
- (2) R.C. Maher, "Evaluation of a method for separating digitized duet signals," J. Audio Eng. Soc., vol. 38, no. 12, pp. 956-979, 1990.
- (1) R.C. Maher and J.W. Beauchamp, "An investigation of vocal vibrato for synthesis," Applied Acoustics, vol. 30, no. 2-3, pp. 219-245, 1990.

BOOKS AND CHAPTERS

These are books and chapters of published reference books with peer review of the completed manuscript.

- (5) R.C. Maher, "Forensic Audio Analysis," book chapter, *Handbuch der Audiotechnik*, 2nd edition, Stefan Weinzierl, ed., Heidelberg: Springer-Verlag, 2022.
- (4) R.C. Maher, *Principles of Forensic Audio Analysis*, book, Springer Nature Switzerland, 2018.
- (3) R.C. Maher, "Overview of Audio Forensics," book chapter, *Intelligent Multimedia Analysis for Security Applications*, Berlin: Springer-Verlag, pp. 127-144, 2010.
- (2) R.C. Maher, "Lossless Audio Coding," book chapter, *Lossless Compression Handbook*, K. Sayood, ed., San Diego: Academic Press, 2003.
- (1) J.W. Beauchamp and R.C. Maher, "Digital Audio," book chapter, *Handbook of Acoustics*, M. Crocker, ed., New York: John Wiley & Sons, pp. 1967-1978, 1997.

FULLY REFEREED CONFERENCE PROCEEDINGS

These are formal papers invited or accepted for a scholarly conference based on full peer review of the completed manuscript.

- (21) R.C. Maher, "Examining tell-tale sounds in forensic gunshot recordings," elib 22634, AES 8th International Conference on Audio Forensics, Denver, CO, June 27-29, 2024.
- (20) S.B. Nesar, B.M. Whitaker, and R.C. Maher, "A geometric approach for generating synthetic gunshot acoustic signals," elib 22631, AES 8th International Conference on Audio Forensics, Denver, CO, June 27-29, 2024.
- (19) S.B. Nesar, B.M. Whitaker, and R.C. Maher, "Machine learning analysis on gunshot recognition," 2024 Intermountain Engineering, Technology and Computing (IETC) Conference, Utah State University, Logan, UT, May 13-14, 2024.
- (18) R.C. Maher, "Shot-to-shot variation in gunshot acoustics experiments," elib 20461, Proc. 2019 Audio Engineering Society International Conference on Audio Forensics, Porto, Portugal, June, 2019.
- (17) D.R. Begault, S.D. Beck, and R.C. Maher, "Overview of forensic gunshot analysis techniques," elib 20475, Proc. 2019 Audio Engineering Society International Conference on Audio Forensics, Porto, Portugal, June, 2019.
- (16) R.C. Maher and T.K. Routh, "Gunshot acoustics: pistol vs. revolver," Proc. Audio Engineering Society Conference, Audio Forensics—Finding Signal in the Noise, Arlington, VA, June, 2017.
- (15) Â.M.C.R. Borzino, R.C. Maher, J.A. Apolinário and M.L.R. de Campos, "Employing wavelet-based texture features in ammunition classification", Proc. SPIE 10184, Sensors, and Command, Control, Communications, and Intelligence (C3I) Technologies for Homeland Security, Defense, and Law Enforcement Applications XVI, 101840D; doi:10.1117/12.2262282, May, 2017.
- (14) R.C. Maher and S.R. Shaw, "Gunshot recordings from digital voice recorders," Proc. Audio Engineering Society 54th Conference, Audio Forensics—Techniques, Technologies, and Practice, London, U.K., June, 2014.
- (13) R.C. Maher and J. Studniarz, "Automatic search and classification of sound sources in long-term surveillance recordings," Proc. Audio Engineering Society 46th Conference, Audio Forensics—Recording, Recovery, Analysis, and Interpretation, Denver, CO, June, 2012.

- (12) R.C. Maher and S.R. Shaw, "Directional aspects of forensic gunshot recordings," Proc. Audio Engineering Society 39th Conference, Audio Forensics—Practices and Challenges, Hillerød, Denmark, June, 2010.
- (11) R.C. Maher, J. Becker, T. Sharpe, J. Peterson, and B.A. Towle, "Development and implementation of a robot-based freshman engineering course," Proc. 2005 American Society for Engineering Education Annual Conference, Portland, OR, June, 2005.
- (10) B.J. Gregoire and R.C. Maher, "Harmonic Envelope Detection and Amplitude Estimation Using Map Seeking Circuits," Proc. IEEE International Conference on Electro Information Technology (EIT2005), Lincoln, NE, May, 2005.
- (9) R.C. Maher, "Concurrent Audio And Modem Acceleration," Proc. 1999 Windows Hardware Engineering Conference (WinHEC), Los Angeles, CA, March, 1999.
- (8) R.C. Maher, "Single-ended spatial enhancement using a cross-coupled lattice equalizer," Proc. 1997 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, Mohonk, NY, October, 1997.
- (7) R.C. Maher, "Simple But Useful Tools for Interactive WWW Development," Proc. 1996 Frontiers in Education Conference, Salt Lake City, UT, November, 1996.
- (6) Y.J. Chen and R.C. Maher, "Subband coding of audio using a recursively indexed quantizer," Proc. 1995 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, Mohonk, NY, October, 1995.
- (5) R.C. Maher, "Computationally efficient compression of audio signals by means of RIQ-DPCM," Proc. 1993 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, Mohonk, NY, October, 1993.
- (4) R.C. Maher, "Control of interharmonic beating in polyphonic music," Proc. 1991 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, Mohonk, NY, pp. 1-2, October, 1991.
- (3) R.C. Maher, "Development and evaluation of a method for the separation of musical duet signals," Proc. IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, Mohonk, NY, pp. 1-2, October, 1989.
- (2) J.W. Beauchamp and R.C. Maher, "Significance of frequency vs. time variations and amplitude beating in additive synthesis of piano tones," Iowa Acoustics Colloquium, Iowa City, IA, p. 1, 1987.
- (1) J.W. Beauchamp and R.C. Maher, "Musical acoustics demonstrations, lessons," Proc. IBM Advanced Education Projects Conference, San Diego, CA, 1986.

FORMAL PROFESSIONAL CONFERENCE PROCEEDINGS

These are formal papers invited or accepted for a scholarly conference by peer review of an abstract or extended summary.

- (69) R.C. Maher, "Interpreting user-generated recordings from the Trump assassination attempt on July 13, 2024," Proc. 187th Meeting of the Acoustical Society of America—Virtual, November 21, 2024.
- (68) R.C. Maher, "Advanced Audio Forensics Analysis," invited presentation, Bellingfest: 10th anniversary of Bellingcat independent investigative organization, Amsterdam, Netherlands, November 14-15, 2024.
- (67) R.C. Maher, "Interpreting user-generated audio from war zones," Express Paper 265, Proc. 157th Audio Engineering Society Convention, New York, NY, October 9, 2024.
- (66) R.C. Maher, "Where is Audio Forensics Heading Today?" invited keynote address, AES 8th International Conference on Audio Forensics, Denver, CO, June 27-29, 2024.
- (65) R.C. Maher, "On Ramp: Engineering Algebra," 89th Annual ASEE Pacific NW Section Conference, Bozeman, MT, March 27-29, 2024.

- (64) R.C. Maher, "Getting Things Started With a Bang: Interpreting Gunshot Sounds in Audio Forensic Analysis," Luncheon Seminar, 76th Annual Conference of the American Academy of Forensic Sciences, Denver, CO, February 22, 2024.
- (63) R.C. Maher, "Close and distant gunshot recordings for audio forensic analysis," Express Paper 122, Proc. 155th Audio Engineering Society Convention, New York, NY, October 25, 2023.
- (62) R.C. Maher, "Audio forensic analysis procedures for user generated audio recordings," presentation with interactive webinar, National Institute of Justice Forensic Technology Center of Excellence, November, 2022.
- (61) R.C. Maher, "Interpretation of audio forensic information from the shooting of journalist Shireen Abu Akleh," Express Paper 22, Proc. 153rd Audio Engineering Society Convention, New York, NY, October 20, 2022.
- (60) R.C. Maher, "Forensic interpretation of user generated audio recordings," 2022 National Institute of Justice Forensic Science Research and Development (R&D) Symposium, virtual event, Online, March 1-2, 2022.
- (59) B.F. Miller, F.A. Robertson, and R.C. Maher, "Forensic handling of user generated audio recordings," Preprint 10515, Proc. 151st Audio Engineering Society Convention, Las Vegas, NV, Online, October, 2021.
- (58) R.C. Maher, "Forensic interpretation and processing of user generated audio recordings," Preprint 10419, Proc. 149th Audio Engineering Society Convention, New York, NY, Online, October, 2020.
- (57) E.R. Hoerr and R.C. Maher, "Estimating nonlinear impulse response length using time-delayed mutual information," Preprint 10416, Proc. 149th Audio Engineering Society Convention, New York, NY, Online, October, 2020.
- (56) R.C. Maher and E.R. Hoerr, "Forensic comparison of simultaneous recordings of gunshots at a crime scene," Preprint 10281, Proc. 147th Audio Engineering Society Convention, New York, NY, October, 2019.
- (55) E.R. Hoerr and R.C. Maher, "Using Volterra series modeling techniques to classify black-box audio effects," Preprint 10225, Proc. 147th Audio Engineering Society Convention, New York, NY, October, 2019.
- (54) R.C. Maher and E.R. Hoerr, "Audio forensic gunshot analysis and multilateration," Preprint 10100, Proc. 145th Audio Engineering Society Convention, New York, NY, October, 2018.
- (53) R.C. Maher, "Challenges of audio forensic evaluation from personal recording devices," Preprint 9897, Proc. 143rd Audio Engineering Society Convention, New York, NY, October, 2017.
- (52) T.K. Routh and R.C. Maher, "Determining muzzle blast duration and acoustical energy of quasi-anechoic gunshot recordings," Preprint 9635, Proc. 141st Audio Engineering Society Convention, Los Angeles, CA, October, 2016.
- (51) R.C. Maher and T.K. Routh, "Wideband audio recordings of gunshots: waveforms and repeatability," Preprint 9634, Proc. 141st Audio Engineering Society Convention, Los Angeles, CA, October, 2016.
- (50) T.K. Routh and R.C. Maher, "Recording anechoic gunshot waveforms of several firearms at 500 kHz sampling rate," Proc. Mtgs. Acoust. 26, 030001 (2016); <http://dx.doi.org/10.1121/2.0000262>, May, 2016.
- (49) R.C. Maher, "Explaining microphones and loudspeakers in a musical acoustics course for non-scientists," invited paper, J. Acoust. Soc. Am., vol. 139, no. 4, part 2, p. 2096 (abstract), April, 2016.
- (48) T. Routh and R.C. Maher, "Recording anechoic gunshot waveforms of several firearms at 500 kilohertz sampling rate," J. Acoust. Soc. Am., vol. 139, no. 4, part 2, p. 2066 (abstract), April, 2016.
- (47) R.C. Maher, "Gunshot recordings from a criminal incident: who shot first?" J. Acoust. Soc. Am., vol. 139, no. 4, part 2, p. 2024 (abstract), April, 2016.
- (46) R.C. Maher and T. Routh, "Advancing forensic analysis of gunshot acoustics," Preprint 9471, Proc. 139th Audio Engineering Society Convention, New York, NY, October, 2015.

- (45) J. Studniarz and R.C. Maher, "Sound identification from MPEG-encoded audio files," Preprint 8984, Proc. 135th Audio Engineering Society Convention, New York, NY, October, 2013.
- (44) R.C. Maher, "A method for enhancement of background sounds in forensic audio recordings," Preprint 8731, Proc. 133rd Audio Engineering Society Convention, San Francisco, CA, October, 2012.
- (43) R.C. Maher, "Teaching and learning musical acoustics in a music technology program," J. Acoust. Soc. Am., vol. 132, no. 3, part 2, p. 1958 (abstract), October, 2012.
- (42) R.C. Maher, "Soundscape collaboration for science, management, and public outreach at a national historic site," invited paper, J. Acoust. Soc. Am., vol. 130, no. 4, part 2, p. 2497 (abstract), October, 2011.
- (41) R.C. Maher, "Acoustical modeling of gunshots including directional information and reflections," Preprint 8494, Proc. 131st Audio Engineering Society Convention, New York, NY, October, 2011.
- (40) R.C. Maher, "Automated analysis and interpretation of long-term soundscape audio recordings," invited paper, J. Acoust. Soc. Am., vol. 129, no. 4, part 2, p. 2570 (abstract), April, 2011.
- (39) R.C. Maher, "Maintaining Sonic Texture with Time Scale Compression by a Factor of 100 or More," Preprint 8250, Proc. 129th Audio Engineering Society Convention, San Francisco, CA, November, 2010.
- (38) R.C. Maher, "Cultural soundscape of the Grant-Kohrs Ranch national historic site," invited paper, J. Acoust. Soc. Am., vol. 127, no. 3, part 2, p. 1745 (abstract), April, 2010.
- (37) D. Reed and R.C. Maher, "An investigation of early reflection's effect on front-back localization in spatial audio," Preprint 7884, Proc. 127th Audio Engineering Society Convention, New York, NY, October, 2009.
- (36) R.C. Maher, "Acoustics of national parks and historic sites: the 8,760 hour MP3 file," Preprint 7893, Proc. 127th Audio Engineering Society Convention, New York, NY, October, 2009.
- (35) R.C. Maher, "Baseline sound monitoring plan for Grant-Kohrs Ranch national historic site," J. Acoust. Soc. Am., vol. 125, no. 4, part 2, p. 2716 (abstract), 2009.
- (34) R.C. Maher, "All about PHASE," Proc. IEEE Signal Processing Society 5th Signal Processing Education Workshop, Marco Island, FL, pp. 218-222, January, 2009.
- (33) R.C. Maher and S.R. Shaw, "Deciphering gunshot recordings," Proc. Audio Engineering Society 33rd Conference, Audio Forensics—Theory and Practice, Denver, CO, June, 2008.
- (32) Z. Chen and R.C. Maher, "Addressing the Discrepancy Between Measured and Modeled Impulse Responses for Small Rooms," Preprint 7239, Proc. 123rd Audio Engineering Society Convention, New York, NY, October, 2007.
- (31) Z. Chen and R.C. Maher, "Modeling room impulse response by incorporating speaker polar response into image source method," J. Acoust. Soc. Am., vol. 121, no.5, part 2, p. 3174 (abstract), 2007.
- (30) R.C. Maher, "Acoustical characterization of gunshots," Proc. IEEE SAFE 2007: Workshop on Signal Processing Applications for Public Security and Forensics, Washington, DC, pp. 109-113, April, 2007.
- (29) R.C. Maher, "Modeling and signal processing of acoustic gunshot recordings," Proc. IEEE Signal Processing Society 12th DSP Workshop, Jackson Lake, WY, pp. 257-261, September, 2006.
- (28) B.J. Gregoire and R.C. Maher, "Map seeking circuits: a novel method of detecting auditory events using iterative template mapping," Proc. IEEE Signal Processing Society 12th DSP Workshop, Jackson Lake, WY, September, 2006.
- (27) R.C. Maher, "Crossing the bridge: taking audio DSP from the textbook to the DSP design engineer's bench," Proc. IEEE Signal Processing Society 4th Signal Processing Education Workshop, Jackson Lake, WY, September, 2006.
- (26) S.M. Pascarelle, B. Stewart, T.A. Kelly, A. Smith, and R.C. Maher, "An Acoustic / Radar System for Automated Detection, Localization, and Classification of Birds in the Vicinity of Airfields," 8th Joint Annual Meeting of Bird Strike Committee USA/Canada, St. Louis, MO, August, 2006.

- (25) R.C. Maher, J. Gregoire, and Z. Chen, "Acoustical monitoring research for national parks and wilderness areas," Preprint 6609, Proc. 119th Audio Engineering Society Convention, New York, NY, October, 2005.
- (24) R.C. Maher, "Audio enhancement using nonlinear time-frequency filtering," Proc. Audio Engineering Society 26th Conference, Audio Forensics in the Digital Age, Denver, CO, July, 2005.
- (23) G. Sanchez, R.C. Maher, and S. Gage, "Ecological and environmental acoustic remote sensor (EcoEARS) application for long-term monitoring and assessment of wildlife," U.S. Department of Defense Threatened, Endangered and at-Risk Species Research Symposium and Workshop, Baltimore, MD, June, 2005.
- (22) J. Gregoire and R.C. Maher, "Map seeking circuits for audio pattern recognition," Music Information Processing Workshop, Whistler, British Columbia, Canada, December, 2004.
- (21) R.C. Maher, "AES Technical Committee on Signal Processing Educational CD Project," Proc. 117th Audio Engineering Society Convention, Preprint 6313, San Francisco, CA, October, 2004.
- (20) R.C. Maher, "Compression and Decompression of Wavetable Synthesis Data," Proc. 2003 Audio Engineering Society Convention, Preprint #5937, New York NY, October, 2003.
- (19) M. Phillips, J. Barish, and R.C. Maher, "The modeling and synthesis of musical signals with PRISM," Proc. 2000 Audio Engineering Society Convention, Preprint #5187, Los Angeles, CA, September, 2000.
- (18) D.K. Reinhardt and R.C. Maher, "A real time DSP kernel for concurrent audio tasks," Proc. 1998 Audio Engineering Society Convention, Preprint #4825, San Francisco, CA, September, 1998.
- (17) R.C. Maher, "A low complexity spatial localization system," Proc. 1997 Audio Engineering Society Convention, Preprint #4567, New York, NY, November, 1997.
- (16) R.C. Maher, E. Lindemann, and J. Barish, "Old and new techniques for artificial stereophonic image enhancement," Proc. 1996 Audio Engineering Society Convention, Preprint #4371, Los Angeles, CA, November, 1996.
- (15) R.C. Maher, "Tunable bandpass filters in music synthesis," Proc. 1995 Audio Engineering Society Convention, Preprint #4098, New York, NY, October, 1995.
- (14) R. Peddibhotla, R.C. Maher and K. Sayood, "A low complexity audio coding scheme for wideband audio," Proc. 1994 Asilomar Conf. on Circuits and Systems, Pacific Grove, CA, vol. 2, pp. 1222-1226, November, 1994.
- (13) R.C. Maher, "An efficient scheme for lossy real-time audio data compression," Proc. 1994 Audio Engineering Society Convention, San Francisco, CA, Preprint #3922, pp. 1-13, November 10, 1994.
- (12) R.C. Maher and J.L. Varner, "Laboratory development for digital signal processing education," Proc. 1994 ASEE Midwest Section Meeting, Lincoln, NE, pp. 1-4, March 31 - April 2, 1994.
- (11) R.C. Maher, "A method for extrapolation of missing digital audio data," Proc. 1993 Audio Engineering Society Convention, New York, NY, Preprint #3715, pp. 1-19, October, 1993.
- (10) J.W. Beauchamp, R.C. Maher, and R. Brown, "Detection of musical pitch from recorded solo performances," Proc. 1993 Audio Engineering Society Convention, Berlin, Germany, Preprint #3541, pp. 1-15, March, 1993.
- (9) D.J. Cheenne, R.D. Kubik, R.C. Maher, and E. Bahar, "Full-wave modeling of the transmission of sound over theater seats: far field investigation," J. Acoust. Soc. Am., vol. 92, no. 4, part 2, p. 2347 (abstract), 1992.
- (8) R.C. Maher and J.W. Beauchamp, "Frequency tracking of solo and duet passages using a harmonic two-way mismatch procedure," invited paper, J. Acoust. Soc. Am., vol. 92, no. 4, part 2, p. 2429 (abstract), 1992.

- (7) E.P. Moss and R.C. Maher, 1992, "Synthesis and processing of audible notification and warning signals," Proc. 1992 Audio Engineering Society Convention, San Francisco, CA, Preprint #3354, pp. 1-10, October, 1992.
- (6) R.C. Maher, "Sinusoidal additive synthesis revisited," Proc. 1991 Audio Engineering Society Convention, New York, NY, Preprint #3128, pp. 1-19, October, 1991.
- (5) R.C. Maher, "Computer processing of audio signals by exclusion filters," J. Acoust. Soc. Am. Suppl. 1, vol. 88, p. 188 (abstract), 1990.
- (4) J.W. Beauchamp and R.C. Maher, "Partial synchrony in musical sounds: some recent results using time-variant spectral analysis," invited paper, J. Acoust. Soc. Am. Suppl. 1, vol. 84, pp. 103-104 (abstract), 1988.
- (3) R.C. Maher and J.W. Beauchamp, "Is there a single vibrato waveform?" J. Acoust. Soc. Am. Suppl. 1, vol. 83, p. 31 (abstract), 1988.
- (2) R.C. Maher and J.W. Beauchamp, "A microcomputer-based demonstration system for acoustics education" J. Acoust Soc. Am. Suppl. 1, vol. 81, p. 32 (abstract), 1987.
- (1) R.C. Maher, J.H. Scandrett, R.E. Crawford, Jr., and K. Grant, "A low-cost digital synthesizer system for music applications and psychoacoustical research," J. Acoust Soc. Am. Suppl. 1, vol. 77, p. 75 (abstract), 1985.

FORMAL PROFESSIONAL PRESENTATIONS

These are formal, invited lectures for an engineering group, academic seminar, employment interview, or technical meeting.

- (70) S. Wettstein, B. LaMeres, P. Gannon, and R.C. Maher, "Implementing a College-Wide Entrepreneurial Mindset Intervention," workshop presentation, 2024 KEEN National Conference, Austin, TX, February 8-10, 2024.
- (69) R.C. Maher, "Gunshot analysis in audio forensics," invited workshop tutorial presentation, SoundThinking, Inc., Washington, D.C., May 25, 2023.
- (68) R.C. Maher, "How to be a great peer reviewer for the AES Journal," invited workshop tutorial presentation, *Audio Engineering Society 153rd Convention*, New York, NY, October 20, 2022.
- (67) R.C. Maher, J. Reiss, V. Välimäki, and B. Kostek, "What does it take to write a paper for the Journal of the Audio Engineering Society?" invited workshop tutorial presentation, *Audio Engineering Society 151st Convention*, Las Vegas, NV, Online, October, 2021.
- (66) R.C. Maher, "Courage, Responsibilities, and Obligations: Teaching and Learning Ethics in Engineering Education," invited lecture presentation, Allan J. McDonald Symposium, *Engineering Courage: Ethics and Professionalism in a Complicated World*, Bozeman, MT, October 2021.
- (65) R.C. Maher, "Understanding acoustics and the principles of sound location via multilateration," live interactive online training course, 6 hours total, Cook County Office of the Public Defender, Chicago, IL, May, 2021.
- (64) R.C. Maher, "Sound Science," live interactive online seminar course, 8 hours total, Osher Lifelong Learning Institute (OLLI), Montana State University, Bozeman, MT, February, 2021.
- (63) R.C. Maher, E. Brixen, K. McElveen, G. Reid, and J. Smith, "What's that sound? An introduction to the field of audio forensic analysis," invited workshop tutorial presentation, *Audio Engineering Society 149th Convention*, New York, NY, October, 2020.
- (62) R.C. Maher, "What's that sound? Audio forensics in 2020," invited lecture presentation, Montana State University "Wonderlust" Special Presentation, Bozeman, MT, June 25, 2020. <https://youtu.be/Rux0ZeRbiwg>
- (61) R.C. Maher, "A half century later, a look back: Apollo 11," invited lecture presentation, moon landing commemorative event, Bozeman Public Library, Bozeman, MT, July 20, 2019. <https://www.youtube.com/watch?v=6ZjjxOhPpJk>

(60) R.C. Maher, "Examining multiple recordings of the same gunshot incident," invited workshop presentation, *Audio Engineering Society International Conference on Audio Forensics*, Porto, Portugal, June 19, 2019.

(59) R.C. Maher, "Blockchain and Cryptocurrency," invited seminar presentation, *Quest for Knowledge Club*, Bozeman, MT, April 17, 2019.

(58) R.C. Maher, "Renewable energy: What's going on with the electrical grid?" video presentation, *TEDx Bozeman*, Bozeman, MT, April 13, 2019. <https://www.youtube.com/watch?v=0oo2CeEkn40>

(57) R.C. Maher, "A Half Century Later, A Look Back: America in 1968," Montana State University "Wonderlust" Special Presentation, Belgrade Public Library, Belgrade, MT, March 21, 2019. <https://youtu.be/vt3HxMRfhl>

(56) R.C. Maher, "Advanced Forensics of Gunshot Acoustics," invited seminar presentation, *10x10 Innovation Roadshow*, Montana State University, Bozeman, MT, March 14, 2019. <https://youtu.be/nPE2F4STwQ0>

(55) R.C. Maher, "Gunshot Acoustics," invited webinar presentation, Forensic Technology Center of Excellence, RTI International, February 26, 2019.

(54) R.C. Maher, "Audio Forensics of Gunshot Sounds," invited seminar presentation, *Leadership MSU*, Bozeman, MT, February 21, 2019.

(53) R.C. Maher, "Sounds of Science: Connections Over a Career," invited keynote address, *Phi Kappa Phi Initiation*, Montana State University, Bozeman, MT, January 29, 2019.

(52) R.C. Maher, "My Sonic Journey: A Love Story," *MSU 994-Calling Seminar*, Bozeman, MT, December 3, 2018.

(51) R.C. Maher "Signal Processing of Acoustic Gunshot Recordings," *MSU Applied Mathematics Seminar*, Bozeman, MT, October 25, 2018.

(50) R.C. Maher, "Understanding Soundscape Ecology in Wilderness, Rural, and Urban Settings," *MSU Institute on Ecosystems Rough Cut Seminar*, November 8, 2017.

(49) R.C. Maher, "The Science of Sound: Blending Music, Physics, and Engineering," MSU Honors Program Seminar, February 23, 2017.

(48) R.C. Maher, "Audio Forensics of Gunshot Sounds," invited seminar presentation, *National Institute of Justice Forensic Science Research and Development Symposium*, American Academy of Forensic Sciences 69th Annual Scientific Meeting, New Orleans, LA, February 14, 2017.

(47) R.C. Maher, "Research in Audio Forensic Analysis," MSU Office of Sponsored Programs Roundtable, April 26, 2016.

(46) R.C. Maher, "Principles of Audio System Grounding and Signal Integrity," invited seminar presentation, *Montana Joint Engineers Conference*, Helena, MT, November 6, 2015.

(45) R.C. Maher, "Gunshot Acoustical Interpretation," invited workshop presentation, *Audio Engineering Society 139th Convention*, New York, NY, October 30, 2015.

(44) R.C. Maher, "Found Sound: Recording Studio, National Park, Courtroom," invited seminar presentation, *MSU Physics Colloquium*, Bozeman, MT, September 18, 2015.

(43) R.C. Maher, "Introduction to academic advising at Montana State University," invited workshop presentation, *2015 New Faculty Orientation*, Bozeman, MT, August 20, 2015.

(42) R.C. Maher, "Acoustical Fingerprinting," invited seminar presentation, *ES23 Executive Summit 2015*, American Board of Recorded Evidence, Santa Barbara, CA, August 7, 2015.

(41) R.C. Maher, "Forensic Audio Authenticity," invited panel presentation, *ES23 Executive Summit 2015*, American Board of Recorded Evidence, Santa Barbara, CA, August 7, 2015.

- (40) R.C. Maher, "Environmental Soundscape Recording," invited workshop presentation, *Third Annual Research and Creative Activity Symposium*, College of Arts and Architecture, Bozeman, MT, January 28, 2015.
- (39) R.C. Maher, "Introduction to academic advising at Montana State University," invited workshop presentation, *2014 New Faculty Orientation*, Bozeman, MT, August 21, 2014.
- (38) R.C. Maher, "Introduction to academic advising at Montana State University," invited workshop presentation, *2013 New Faculty Orientation*, Bozeman, MT, August 22, 2013.
- (37) R.C. Maher, G. Young, B. Clinton, and J.P. Miller, "The Science of Sound: Decomposing Music," invited seminar presentation and live demonstration, *Montana State University President's Fine Arts Series*, Bozeman, MT, March 4, 2013.
- (36) R.C. Maher, "Sounds of silence and sounds of rivers," invited seminar presentations, *Montana Institute on Ecosystems Rough Cut Seminar Series*, Missoula, MT, September 17, 2012, and Bozeman, MT, September 19, 2012.
- (35) R.C. Maher, "Introduction to academic advising at Montana State University," invited workshop presentation, *2012 New Faculty Orientation*, Bozeman, MT, August 23, 2012.
- (34) R.C. Maher, "Soundscape management: the impact of change on soundscape," invited workshop presentation, *2012 Teacher Workshop, Grant-Kohrs Ranch National Historic Site*, Deer Lodge, MT, June 13, 2012.
- (33) R.C. Maher, "The Science of Sound: Acoustics and Audio Engineering," invited seminar presentation, *Aspen Pointe Speakers Series*, Bozeman, MT, September 23, 2010.
- (32) R.C. Maher, "Speech Production and Intelligibility," invited seminar presentation, *Gallatin Ham Radio Club*, Bozeman, MT, March 4, 2010.
- (31) R.C. Maher, "Forensic Acoustical Interpretation," invited workshop presentation, *Audio Engineering Society 127th Convention*, New York, NY, October, 2009.
- (30) R.C. Maher, "Baseline Sound Monitoring at Grant-Kohrs Ranch National Historic Site," invited workshop presentation, *National Cooperative Ecosystem Study Unit (CESU) Coordinators Meeting*, Deer Lodge, MT, May, 2009.
- (29) R.C. Maher, "Gunshot Acoustics for Audio Forensics," invited workshop presentation, *Audio Engineering Society 125th Convention*, San Francisco, CA, October, 2008.
- (28) R.C. Maher, "Research Trends in Digital Audio," invited seminar presentation, *MSU Physics Colloquium*, Bozeman, MT, January 18, 2008.
- (27) R.C. Maher, "Audio Science for Ham Radio Operators," invited seminar presentation, *Gallatin Ham Radio Club*, Bozeman, MT, December 6, 2007.
- (26) R.C. Maher, "Science and engineering demonstrations and opportunities," general interest PR presentation, *MSU For a Day*, Belgrade, MT, November 27-28, 2007.
- (25) R.C. Maher, "Acoustical gunshot analysis," invited seminar presentation, *Montana Audio and Acoustics Society*, Bozeman, MT, October 24, 2007.
- (24) R.C. Maher, "MS or PhD in EE/CS: Should I Go To Graduate School?" invited seminar presentation, *Audio Engineering Society 121st Convention*, San Francisco, CA, October, 2006.
- (23) R.C. Maher, "Robots for Space Exploration," invited seminar presentation, Laurel High School seminar, *Montana Space Grant Consortium*, Bozeman, MT, January, 2006.
- (22) R.C. Maher, "A Primer on Microphones and Loudspeakers," invited seminar presentation, *Montana Audio and Acoustics Society*, Bozeman, MT, August, 2005.
- (21) R.C. Maher, "Robots for Space Exploration," invited seminar presentation, Winifred High School teleconference, *Burns Telecommunications Center*, March, 2005.

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- (19) R.C. Maher, "Principles of MP3 and Other Perceptual Audio Coders," invited seminar presentation, *Montana Society of Engineers—Bozeman Chapter*, Bozeman, MT, April, 2004.
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- (16) R.C. Maher, "Technical Report on the 115th Audio Engineering Society Convention," invited seminar presentation, *Montana Audio and Acoustics Society*, Bozeman, MT, October, 2003.
- (15) R.C. Maher, "Principles of Perceptual Audio Data Compression," invited seminar presentation, *Research Methods in Engineering Graduate Course*, Bozeman, MT, October, 2003.
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- (5) R.C. Maher, "Signal Processing Aspects of Electronic and Computer Music," *Communications and Control Seminar Series*, University of Nebraska-Lincoln, January, 1991.
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- (27) R.C. Maher, "Sonata Quarta in D Major, from *Sonatae Unarum Fidium*" (1664) by Johann Heinrich Schmelzer, audio recording, Baroque Music Montana, broadcast nationally on *APM Performance Today*, September 18, 2023, December 28, 2023, and March 28, 2024.
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